Soil C and N Fractions in Cropping Systems Integrated with Livestock

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Financial Support

USDA-ARS Soils CRIS (6612-11120-003-00D) *"Soil Organic Matter and Nutrient Cycling to Sustain Agriculture in the Southeastern USA"*

USDA-CSREES-National Research Initiative (Agreement No. 2001-35107-11126) *"Rotation of Pastures with Crops to Achieve Productivity and Environmental Quality"*

Georgia Commodity Commission for Corn *"Response of Corn to Organic Matter Quantity and Distribution in Soil"*

Issues

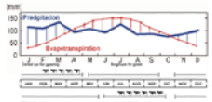
To till or not to till...
Conservation tillage know to benefit soil. If not tilled, will soil be compacted?

To graze or not to graze...
Grazing could diversify income. Will grazing compact soil and change nutrient dynamics?

To graze in the summer or in the winter...
Will cattle grazing during wet period in winter/spring cause compaction?

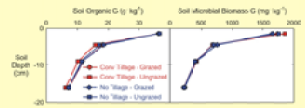
Methods

- Set of 32 plots previously in tall fescue for 20 yr on Cecil sandy loam in Watkinsville GA
- Treatments (4 replications each) were a factorial of
  - Cropping system
    - –summer grain + winter cover (SGWC)
    - –winter grain + summer cover (WGSC)
  - Tillage management
    - –conventional tillage (CT)
    - –no tillage (NT)
  - Cover crop management
    - –grazed by cattle (0.5 ha)
    - –ungrazed (0.2 ha)
- All crops received topdressing of ca. 40 kg N/ha
- Yearling steers during Year 1, cow/calf pairs during Years 2 and 3
- Soil collected from 5 to 8 cores (4-cm diam) in a plot on a yearly basis and separated into depths of 0-3, 3-6, 6-12, 12-20, and 20-30 cm
  - Bulk density (weight / volume of 5-5 cores)
  - Soil organic C and N (dry combustion)
  - Particulate organic C and N (dispersion, sieving through 0.053 mm, dry combustion)
  - Microbial biomass C (CHCl3 fumigation-incubation without subtraction of control)
  - Potential C and N mineralization (incubation at 25 C and 50% water-filled porosity for 24 days)
  - Flush of CO_2 following rewetting of dried soil during 3 days (25 C, 50% water-filled porosity)
  - Water-stable aggregation (oscillation of soil on nest of 10, 0.25, and 0.05-mm sieves, 10 min)
  - Aggregate-associated C and N (dry combustion of >1, 0.25-1.0, and 0.05-0.25 mm fractions)

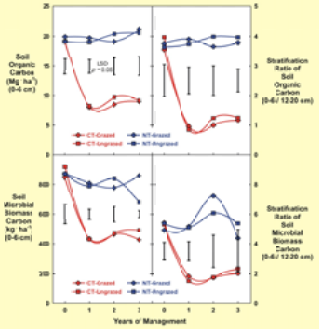


Results

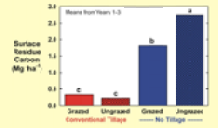
Soil organic C and N fractions at the initiation of this integrated crop/livestock study were highly enriched, especially within the surface 6 cm of soil. Surface-soil enrichment was due to the 20-year history of tall fescue management, which allowed permanent soil cover without disturbance by tillage.



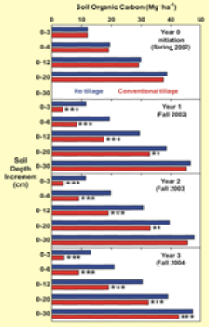
With inversion tillage (CT - moldboard plow initially, disk tillage thereafter), soil C and N fractions declined in the surface 6 cm of soil, but became enriched below 12 cm.



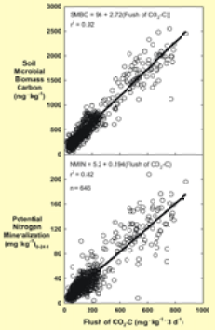
Surface residue was tilled under with CT biannually resulting in low surface protection. Cattle grazing did reduce surface residue C, but not soil organic C under NT.



To a depth of 30 cm, there was less than overwhelming evidence of a loss of soil organic C with CT compared with NT. Time will be a factor to strengthen conclusion.



The flush of CO_2-C during 3 days of incubation following rewetting of dried soil was highly related to soil microbial biomass C and potential N mineralization, confirming previous findings with this assay.



The effect of periodic cattle grazing during the first 3 years on surface soil properties was minimal, but resulted in some positive and some negative effects.

	Ungrazed	Grazed	Pr > F
0-6-cm depth			
Bulk density (Mg/m3)	1.26	1.24	0.71
Flush of CO_2-C (kg/ha)	172	190	0.01
N mineralization (kg/ha/24 d)	37.9	38.4	0.87
Inorganic N (kg/ha)	10.4	12.9	0.03
0-3-cm depth			
Macroaggregate stability (g/g)	0.89	0.91	0.23
Mean-weight diameter (mm)	1.01	0.89	0.03

Depth distribution of soil C and N fractions at the end of 3 years of management

Summary and Conclusions

- Stratification of soil C and N fractions with depth was maintained with NT, but eliminated with CT following cropping of a long-term pasture.
- Positive effects of NT compared with CT occurred in the surface 6 cm of soil.
- Negative effects of NT compared with CT occurred below 12 cm due to incorporation of residues with CT that enriched organic fractions.
- On balance, statistically significant loss of soil C and N fractions occurred with CT, but not as dramatically as previous literature suggests. Accounting for full-profile contents is important.
- The short-term biological activity assay (i.e., flush of CO_2-C following rewetting of dried soil) could be used as an indicator of biological soil quality.
- Cattle grazing impacts on soil C and N fractions were relatively minor, suggesting that integration of crops and livestock has the potential to:
  (1) diversify farm operations,
  (2) utilize synergies among systems,
  (3) avoid negative environmental outcomes, such as loss of soil quality.
- Pasture / crop rotations should be managed with conservation tillage to preserve the high quality of soil C and N fractions developed under pasture.